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EXTENSION

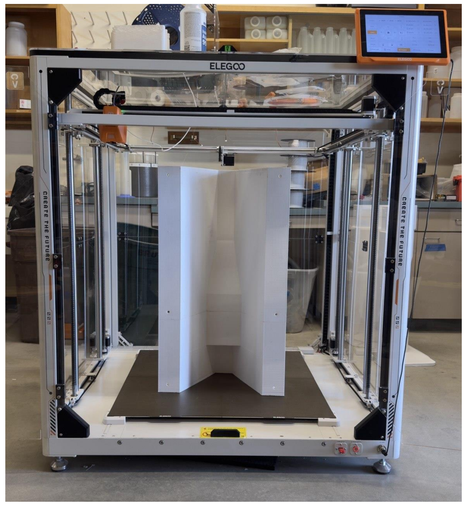
3D PRINTING FOR IRRIGATION FLOW MEASUREMENT

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PROJECT INTRODUCTION

- Accurate flow measurement is critical for irrigation management and water accounting, but commercial flumes can be costly and slow to obtain. RBC (Replogle-Bos-Clemmens) flumes offer a reliable, low-maintenance option thanks to their predictable head-discharge relationship and resistance to sediment and debris.
- This project explores 3D printing as a low-cost way to produce these flumes. Three 150 mm RBC flumes were modelled and printed using different nozzle sizes (0.6, 0.8, and 1.0 mm) and print settings, then lab-tested against the standard RBC discharge rating. Larger nozzle sizes reduced measurement accuracy, showing that print resolution directly affects hydraulic performance.
- We also built a web app that recommends the right flume for a given canal geometry, making flume selection and deployment easier in the field.



INTERNSHIP GOALS

- Model and 3D print three 150mm RBC flumes using three different nozzle sizes.
- Compare how layer height and print settings affect total print time and surface roughness.
- Calibrate each flume to determine whether print settings affect performance against the published RBC calibration curve.
- Build a flume-recommendation app to help farmers select the right flume for their site.

HOW DOES THIS APPLY TO YOUR EDUCATION

- Builds foundation in sensing and measurement systems for agricultural signal processing.
- Hands-on experience with CAD/3D-printing workflows and statistical calibration analysis.
- Builds practical skills in experimental design, uncertainty analysis, and data-driven engineering decisions.

WHAT YOU DID

- 3D printed three 150 mm RBC flumes in PETG using 0.6, 0.8, and 1.0 mm nozzles.
- Assembled and installed the flumes in a laboratory open-channel test facility.
- Calibrated each flume against a magnetic flow meter using multiple discharge–depth measurements.
- Compared hydraulic accuracy using mean, RMS, and maximum discharge errors.
- Evaluated the tradeoff between print speed, print quality, and hydraulic performance across nozzle sizes.
- Developed a Flume Recommender app to help users select a flume from flow range, available head, and channel dimensions.
- Explored large-format 3D printing as a lower-cost alternative to conventional irrigation flumes.

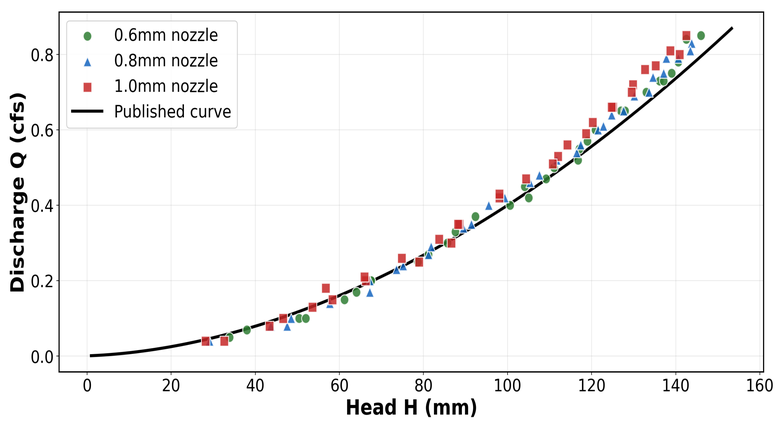


Calibration Video

Flume Recommender App

Figure 1.

150mm RBC rating curves for all three printed flumes compared to the published calibration curve



WHAT YOU LEARNED

- Smaller nozzles gave better accuracy: RMS error increased from 7.1% (0.6 mm) to 8.2% (0.8 mm) and 11.0% (1.0 mm).
- Faster printing came with lower accuracy: the 1.0 mm nozzle printed fastest but had the highest error.
- Operator readings affected the results: point-gauge technique introduced errors similar in size to the nozzle effect.
- The correct head-reference datum was essential: an early reference mistake caused about 65% apparent error before it was corrected.
- Calibration depends on the full measurement process: printing quality, installation, water-depth readings, and data processing all influenced accuracy.
- 3D-printed flumes showed good potential for irrigation measurement, with nozzle size chosen based on the needed balance between speed, cost, and accuracy.

Flume	0.6mm	0.8mm	1.0mm
Number of sample points	31	32	32
Mean Error	-0.04%	+1.37%	+5.67%
Median Error	+3.00%	+4.63%	+8.96%
Standard Deviation	7.18%	8.17%	9.60%
RMS	7.06%	8.15%	11.01%
Max |Error|	19.9%	25.1%	28.7%

Discharge Error Statistics by Nozzle Size

Table 1.

Print settings by nozzle size (Elegoo OrangeStorm Giga, PETG)

Setting	0.6mm	0.8mm	1.0mm
Layer height	0.36 mm	0.48 mm	0.6 mm
Line width	0.62 mm	0.82 mm	1.0 mm
Wall loops	3	3	3
Infill density / pattern	20% cubic	15% crosshatch	15% crosshatch
Max volumetric speed	21mm³/s	50mm³/s	50mm³/s
Print time (both parts)	3d 19h	3d 17h	2d 16h

NEXT STEPS

- Fully develop the Flume Recommender app so users can design a flume from scratch based on site-specific flow and channel requirements.
- Automatically generate the flume geometry and dimensions from the selected design inputs.
- Generate a printable STL file directly from the app, creating a design that is ready for 3D printing.
- Validate the app-generated designs through additional laboratory and field testing.
- Expand testing across nozzle sizes, materials, and flume replicates to improve design and printing recommendations.
- Field-test 3D-printed flumes in real irrigation channels with farmer and irrigation-manager feedback.
- Standardize calibration and measurement procedures to reduce operator-to-operator variability.